IMPORTANCE OF ENERGY MANAGEMENT IN FOUNDRIES

Seweryn Jarża *

Abstract: Pollution prevention is preferable to reliance on end-of-pipe pollution control. Since we look at the environment in the global sense, it is irrelevant that the emissions reductions occur at the electrical generating station rather than at the site of the efficiency improvements. In foundries as a part of an energy intensive industry, energy accounting is necessary to determine where and how energy is being consumed and how efficient is the energy management system. The main aim of energy management should define the areas of high energy use, energy waste and should point out areas in which energy saving can be accomplished. Energy management is very important as it deals with adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements.

Keywords: emission, environment, pollution prevention, energy management

Introduction

Cleaner production encompasses production processes and management procedures that entail less use of resources than conventional technologies and also generate less waste and smaller amounts of toxic or other harmful substances. It emphasizes the human and organizational dimensions of environmental management, including good plant operation to avoid deliberate or accidental discharges. Cleaner production and pollution prevention reduce the quantities of waste and eliminate some pollutants, but treatment and disposal of remaining wastes are also required. Improved energy efficiency reduces greenhouse gas emissions in two ways:

- Energy efficiency measures for on-site combustion systems (e.g., furnaces, boilers, cupolas, heat-treating ovens) reduce emissions in direct proportion to the amount of not consumed fuel.
- Reductions in consumption of electricity lead to reductions in demand for electricity and, consequently, reductions in emissions from thermal electric power generating stations.

We have to remember that the key environmental issues included emissions to all environmental media; energy consumption has the first place but other environmental issues (such as consumption of raw materials, emission of noise, vibration, heat) and other factors can't be overlooked.

According to data of International Energy Agency world primary energy demand is expected to increase 1.5% per year between 2007 and 2030. Separately by source of energy world, electricity use is expected to growth at an annual rate of 2.5% to 2030 and oil demand by rate of 1%. More than 80% of this growth is related to the OECD (Organization for Economic Co-operation and Development) countries. Industry sector consumes produced electricity in the world with rate

* **PhD. Seweryn Jarża,** Czestochowa University of Technology Poland

about 42.2%. Increase in use of energy and fuels have consequence of rising CO2 emission with the predictable growth rate of 1.5% over the mentioned period[1][1].

Energy intensive sectors like petrochemical sector, iron and steel sector and non-metallic mineral sector account approximately 50% of the total final energy use both in OECD and non-OECD countries (Fig.1).

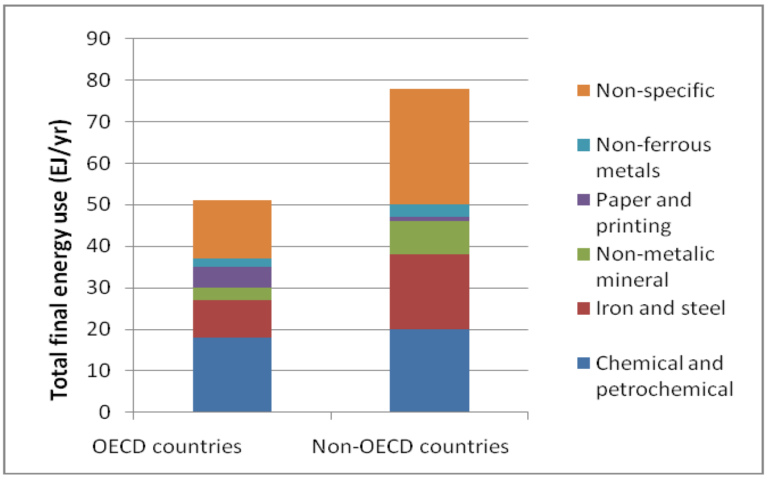

Figure 1. Breakdown of total final industrial energy use in OECD and non-OECD countries in 2007. ***Source: IEA, 2009a,b***

As the foundry industry is an energy intensive industry, focusing on its energy use and ways to reduce and save the energy in this industry is considerable.

No.	Description	Energy Consumption
1	Specific Power Consumption norm in Induction furnace per ton of liquid metal	620 kWh/ton
2	Specific coke consumption norm in cupola per ton of liquid metal	135 Kg/ton

Table 1 Energy consumption in melting process[2][2].

Table 1 shows the specific energy consumption understood as the energy consumed per ton of liquid metal produced. BAT (best available techniques) are the most effective in achieving a high general level of protection to the environment as a whole and for melting process induction furnaces in place of cupola furnaces are preferred.

[1] IEA (International Energy Agency), 2009 a, World energy outlook, executive summary. 2009, available on http://www.worldenergyoutlook.org/docs/weo2009/WEO2009_es_english.

[2] data according to Arasu M., Rogers JL "Energy consumption studies in cast iron foundries" Transactions of 57th Indian Foundry Congress, Kolkata, India, 2009

As it's easy remarkable on fig. 2, the other main processes in energy consumption are molding and cores preparation. These processes creates large quantities of pollution as well.

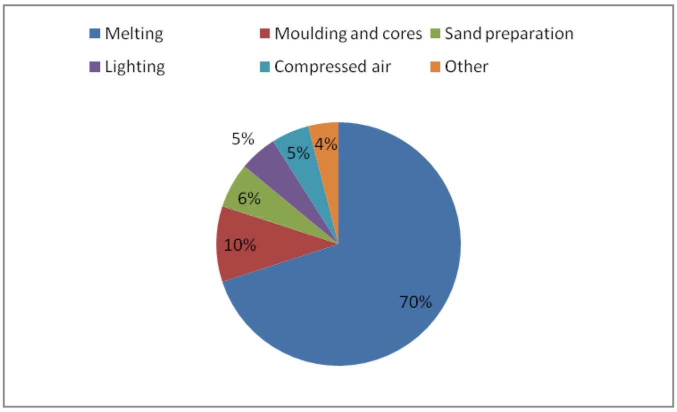

Figure 2. Typical distribution of energy consumption in foundries

So the conventional energy and material efficiency policy in foundries which yields about 1 % annual increase in resource efficiency will not be sufficient to meet necessary challenges.

Profile of foundry industry

Metal castings are the first step in the manufacturing chain and of most durable goods. Foundry operations have always been varied and complex, and they have become even more so. Castings of iron, steel, light metals (such as aluminum), and other metals (such as copper and zinc) are made in units that may be independent or part of a production line. The main production steps include:

- preparation of raw materials,
- metal melting,
- preparation of molds,
- casting
- finishing (which includes fettling and tumbling).

Presently an electric induction furnaces are used to melt iron and other metals. However, large component foundries and some small foundries melt iron in gas or coke-fired cupola furnaces and use induction furnaces for aluminum. Melting capacities of cupola furnaces generally range from 3–25 metric tons per hour (t/h). Induction furnaces are also used in zinc, copper, and brass foundries. Electric arc furnaces are usually used in stainless steel and sometimes in copper foundries. Complete mold is filled with molten metal, using ladles or other pouring devices. Large foundries often have pouring furnaces with automatically controlled pouring process. For hollow casting, the mold is fitted with a core. Finishing processes such as fettling involves the removal from the casting of the gating system, fins (burrs), and sometimes feeders. This is accomplished by cutting, blasting, grinding, and chiseling. Small items are usually ground by tumbling, carried out in a rotating or vibrating drum, usually with the addition of water, which may have surfactants added to it.

Emissions from the melting and treatment of molten metal, as well as from mold manufacture, shakeout, cleaning and after-treatment, is generally of greatest concern. To reduce the emissions and to keep the emissions as low as necessary it is indispensable to implement technical measures which gives an opportunity for creating the tasks and strategy. Integrated index of energy consumption per standard unit is one of the main measure. The rapid escalation of natural gas prices and the deregulation of the electricity market have spotlighted the need to address energy efficiency issues. . In Canadian grey iron foundries melting accounts for 66% of the energy consumption; in steel foundries it is 50%; and in brass and bronze foundries, the figure is 38%. As can be calculated, on average, the total energy content in iron castings is 50% higher, in steel castings 60% higher, and in brass and bronze castings 100% higher than the energy required to melt of the metals[3]. . This gives an idea of the current energy consumption of the foundries, which can be compared with standard norms and can be used to implement deviation control methods. This is also the challenge for exploration the various avenues for energy savings and cost control.

Energy management

Energy management is an ongoing concern in any foundry. Its success depends on a team effort starting with a firm commitment from the top executive and his or her management team. Since the primary business goal is financial savings, managers must understand the principle of economics and run their department as if it were their own business. Currently, there appears to be a lack of reliable information on the total production and benchmarking data of Polish foundries; no single organization is known to keep track of all of it. Publishing of consolidated reports by Foundry Research Institute in Cracow relating to cast iron industry was initiated in 2010 but these reports aren't easy available. The steep escalation of energy prices, together with concerns about market competitiveness, control of greenhouse gas emissions and energy supply security, added urgency to the need to examine the effectiveness of energy use in foundries. In doing so, improving energy efficiency should get proper attention. In table 2 the expecting areas of energy saving are shown. The table 2 is a compilation of results from many energy audits of Canadian foundries undertaken in the few past years by CANMET (Canada Centre for Mineral and Energy Technology).

[3] data according to Guide to Energy Efficiency Opportunities in Canadian Foundries, available on oee.nrcan.gc.ca/cipec/ieep/newscentre/foundry/index.cfm

Equipment / process	Consumption of total plant energy, %	Area savings potential, %	Overall plant savings, %
Melting	**59**	**15**	**9**
Fans and pumps	**6**	**35**	**2**
Lighting	**6**	**30**	**2**
Motors	**12**	**10**	**1**
Air compressors	**5**	**20**	**1**
Miscellaneous	**12**	**10**	**1**
Total	**97***	**-**	**16**

Table 2. Summary of expected results based on end use consumption[4]
* Variation due to unaccounted influences

Energy management is the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output by keeping constant or reducing total costs of producing the output from these systems. The term energy management can be considered as consisting of three basic steps - planning, execution and control so an energy management program follows the same principles that apply to any purposeful undertaking (e.g., to quality and environmental management systems) - principles that Dr. Deming formulated as the cycle: Plan - Do - Check - Act, (PDCA). As all effective activity the energy efficiency effort must have a defined focus, accountability and responsibility. Therefore the first assignment in energy saving activity must be the initial energy audit. It is a key step that establishes the baseline from which the future energy efficiency improvements van be measured. One of the main results of energy audit is the possibility of determination of the energy consumption pattern. The energy pattern is the key in understanding the way energy is used in a foundry and helps to control energy cost by identifying areas where waste can occur and where scope for improvement may be possible. Subsequently every process must be made accountable for optimum energy usage and quantified study should be made for energy savings. The results shown in table 2 can be very helpful in these proceeding. The management must formulate a plan for usage of energy and make a step-by-step procedure for its implementation.

So we can try to summarize the necessary steps for creating the energy management program for foundries:

- Foundry energy audit
- Identify foundry opportunities
- Evaluating impacts of foundry opportunities
- Prioritizing foundry projects
- Implementing energy management program as a part of foundry management system.

[4] Guide to Energy Efficiency Opportunities in Canadian Foundries, available on oee.nrcan.gc.ca/cipec/ieep/newscentre/foundry/index.cfm

There are some of key problems concerned to mentioned procedure. The first we have to start up are the energy and material (mass) balances. They serve to account for all energy inputs and outputs (including waste streams) for a given balance type. Balances which ought to calculate first of all are:

- Power balance
- Coke, natural gas (and/or oil) balance
- Steam and condensate balance
- Water balance
- Material balance (from raw material to good castings)
- Sand balance,
- Cores fabrication balance etc.

Looking for energy losses, one should also pay attention to the process equipment and how it is used. For example, assess melting and holding furnaces and their lids; the state of their repair; how the ladles are preheated; how the molten metal is conveyed, handled and poured; what the temperature gradients are at each stage; etc.

As well as straight energy consumption, we ought to consider examining casting yield and scrap rate and how the scrap is utilized because casting yield greatly influences materials and energy consumption. The next key problem is connected with heat wasting. Waste heat is the rejected heat released from a process at a temperature higher than the temperature of the foundry air. Even a casual look will show many sources of waste heat: in melting furnace exhaust, ladle preheating, core baking, pouring, shot-blasting, castings cooling, heat-treating, ventilation exhaust, etc. O course we can find much more areas of energy saving like:

- Cupola start-ups and shutdowns
- Induction furnace preheating
- Furnace dust collectors
- Cooling water
- Sand-cooling equipment etc.

In production activity not only shown above exemplary ones but all emissions should be monitored continuously Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. A process which needs a minimum energy is least polluting for the environment.

Conclusion

As it was shortly presented above, identifying energy management opportunities we can find the following broad categories:

- **Organizational changes** - the changes in planning and scheduling production in a way that allow for a partial or across-the-board leveling of energy use, hence its better utilization;

- **Process changes** - improvements in process equipment and technological changes that result in reduced energy consumption;
- **Energy efficiency of melting and possibility of fuel substitution** - maximizing the efficiency of use and selecting the best source of energy (e.g., electrical power or natural gas);
- **Electric power management** - measures resulting in reduced electricity consumption, including power demand and power factor management, and cogeneration;
- **Heat recovery** - re-use of waste heat streams and their integration and prevention of heat losses in all forms (e.g., heat exchanger, insulation).

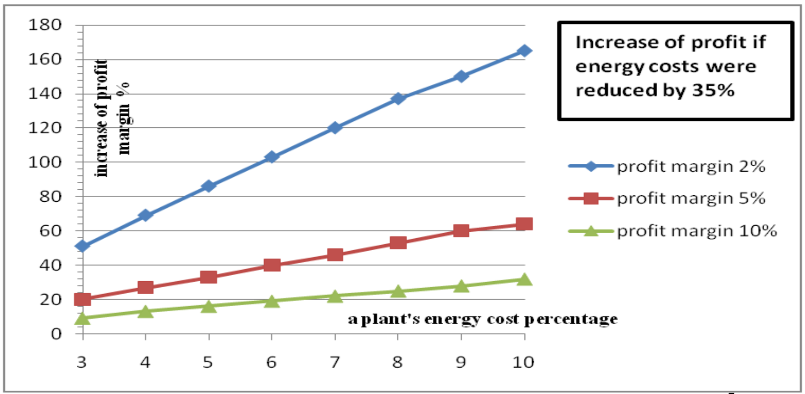

Figure 3 Estimation of profit increase from energy savings[5]

The initial individual list of projects should be scrutinized from several viewpoints. All available information, such as good engineering practice, experience of others, supplier information, literature, consultants and possible synergies ought to be examined.

Monitoring energy performance helps managers identify wasteful areas of their department and lets them take responsibility for energy use. When monitoring shows that energy consumption is declining as improvements are being made, attention can be turned to the next area of concern. Of course the main tasks of our environmental efforts can't cover the maximizing of profitability. On fig. 3 the estimation of profit increase was shown in the situation when energy costs were reduced by 35%. We can easy find that the less current profit margin makes the bigger increasing of expected results.

In our present policy pollution prevention is preferable to reliance on end-of-pipe pollution control. Cleaner production encompasses production processes and management procedures that entail less use of resources than conventional technologies and also generate less waste and smaller amounts of toxic or other

[5] data according to Guide to Energy Efficiency Opportunities in Canadian Foundries, available on oee.nrcan.gc.ca/cipec/ieep/newscentre/foundry/index.cfm

harmful substances. It emphasizes the human and organizational dimensions of environmental management, including good plant operation to avoid deliberate or accidental discharges.

References

[1] Guide to Energy Efficiency Opportunities in Canadian Foundries, available on oee.nrcan.gc.ca/cipec/ieep/newscentre/foundry/index.cfm
[2] IEA (International Energy Agency), 2009 a, World energy outlook, executive summary. 2009, available on http://www.worldenergyoutlook.org/docs/weo2009/WEO2009_es_english
[3] Arasu M., Rogers JL *Energy consumption studies in cast iron foundries*, Transactions of 57th Indian Foundry Congress, Kolkata, India, 2009
[4] Laurence V. Whiting, *Use of electricity in Canadian iron foundries*, Canadian Centre for Mineral and Energy Technology, June 2000.

Streszczenie: Globalne spojrzenie na problemy środowiskowe pozwala stwierdzić, że zmniejszenie emisji wynikające ze zmniejszenia zużycia energii ma miejsce w elektrowniach a nie odnosi się do miejsc gdzie bezpośrednio wprowadzane są usprawnienia. Głównym celem zarządzania energią jest określenie obszarów, w których występuje duże zużycie energii, gdzie dochodzi do dużych strat energii oraz wskazanie takich gdzie oszczędności energii będą możliwe do realizacji. Odlewnie należące do energochłonnych gałęzi przemysłu wymagają kontroli zużycia energii, aby można było określić gdzie, w jaki sposób energia jest wykorzystywana oraz jak efektywny jest system zarządzania energią. Przedstawiono niektóre aspekty zużycia energii w odlewni oraz wskazano główne obszary gdzie dochodzi do strat energii oraz możliwości wprowadzania usprawnień. Wskazano jak zarządzanie energią wpływa na kierunki i efektywność zużycia energii a procedury wynikające z tego systemu umożliwiają ograniczenie zapotrzebowania na energię.

Słowa kluczowe: emisja, środowisko, zapobieganie zanieczyszczeniom, zarządzanie energią.

能源管理的重要性，鑄造廠

污染防治依赖于尾管污染控制。由于从全球意义上的环境来说，污染的减排发生在电站而　　不是在提高效率的地方　　在作为能源密集型产业一部分的铸造厂中，为了确定能源在哪里　　消耗、　　如何消耗以及能源管理系统的效率，能源描述是必要的。能源管理的主要目的应当指出高能源使用、能源浪费的领域，还应当指出可以实现节能的领域。能源管理对于减少
能源需求是非常重要的，因为它涉及调整和优化能源使用的系统和程序。